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CARL J. GEORGE

Biological Laboratories
American University of Beirut
Beirut, Lebanon

THE USE OF BEACHED VALVES OF THE LAMELLIBRANCH
MOLLUSCS *GLYCIMERIS GLYCIMERIS* (L.), *DONAX*
SEMISTRIATUS POLI AND *DONAX TRUNCULUS* L. FOR
THE DETERMINATION OF PERCENTAGE MORTALITY BY
NATICA SPP. (*)

INTRODUCTION

The valves of the lamellibranch molluscs *Glycimeris glycimeris* (L.), *Donax trunculus* L., and *Donax semistriatus* Poli are common on the sandy beaches of Lebanon. These valves are usually in good condition showing little wear and are concentrated in the wave wrack. The presence of such large numbers of valves, many of which bear the holes of boring molluscs (e.g. *Natica* spp.), led the author to ask the question: Is it reasonable to approximate the contribution to mortality (or percentage mortality) and other population parameters of the three named bivalve species using their beached valves? The special use of the phrase *contribution to mortality* should be noted as the word *mortality* as is generally used refers to the percentage of a living population, year class or length interval class which dies.

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In the case here mortality is not determined. The percentage of deaths within the dead population due to a specific cause is approximated instead. Thus the product of mortality, contribution to mortality, and population size is equal to the number of individuals dying from a specific cause.

METHODS AND MATERIALS

Jnah' Beach, immediately south of Beirut, Lebanon, was selected for the study. This beach demarcated by rocky headlands is about 1200 meters long and has a north-south orientation. Its width varies with the season diminishing with the winter storms of December through March and growing during the calmer months to a maximum width of about 70 meters. The prevailing south westerly winds strike the beach obliquely producing a northward moving along-shore current of variable strength. Off-shoreward moving rip currents associated with channels and narrowing of the beach are usually evident. The offshore slope of the beach is gentle and is composed of active sands which produce migratory bars. Sand and gravel cusps of 7 to 15 meter interval move northward during the more turbulent periods. Two or more off-shore freshwater springs provide a slight freshening influence. Pollution due to several adjacent sewer outfalls is slight to negligible as is indicated by a minimum of water discoloration and domestic flotsam.

Hundreds of swimmers use the beach in the late spring and fall vanishing from the area in the summer with the annual migration to the cooler mountains. Tar concretions and other kinds of flotsam are concentrated in the wave wrack. The ghost crab, *Ocypode cursor* (L.), is one of the most conspicuous inhabitants of the area producing a vast complex of holes, mounds and tracks. One census indicated the presence of about 50,000 individuals.

Valves were collected by sieving about five liters of sand and shell debris taken from the wave wrack at eleven points regularly spaced at one hundred meter intervals along the entire span of the beach. Large samples seemed necessary in order to improve the reliability of percentages of drilling. These sieved materials were then placed in plastic bags and transported to the laboratory where extraneous materials, including a few broken valves were removed. The intact valves were then sorted by species, lengthed by 4 mm. intervals and counted for the number of drilled and undrilled valves. Drilling was invariably the work of naticid gastropods. *Natica josephina* Risso, *N. dillwyni*

Payraudeau, *N. millipunctata* Lamarck and *N. hebraea* are most likely the species involved (POLLARY, 1938). The location of the drill hole was recorded as to the left or right valve and to the location on each valve.

The valves of the three species were examined for annuli but due to the presence of other irregularities in growth this data was discarded. It is believed, however, that local populations generally conform to those described by other workers. (COE, 1953, 1955, 1957; HEDGPETH, 1953, 1957; JACOBSON, 1955; MORI, 1938, 1950).

The assistance of Mrs. Victoria Athanassiou and Mr. Peter Davies in sizing and sorting the study material are most gratefully acknowledged.

RESULTS

The number of valves of *Glycimeris glycimeris* were about two and one half times as abundant (10,809) as those of *Donax semistriatus* (4,146) and *Donax trunculus* (4,408). Length-frequency of *G. glycimeris* was strongly unimodal and negatively skewed centering on the 4 to 8 mm length interval. The highest length interval occupied by *G. glycimeris* was that of 32 to 36 mm. *D. semistriatus* reached sizes of 24 to 28 mm with a mode falling in the 8 to 12 mm. interval. The length-frequency plot of *D. trunculus* was bimodal with modes falling in the 8 to 12 mm. and 24 to 28 mm. intervals. Maximum valve size for this species was 28 to 32 mm. *D. trunculus* is, on the basis of the sample, clearly the larger of the two donacids. 17.4% of all *G. glycimeris* valves were drilled while only 7.1% and 3.5% of *D. semistriatus* and *D. trunculus* valves, respectively, were drilled. The highest incidence of drilling for *G. glycimeris*, *D. semistriatus* and *D. trunculus* fell in the 12 to 16 mm., 16 to 20 mm., and 8 to 12 mm. intervals, respectively. Intervals of maximum drilling incidence are not clearly related to intervals containing the largest total number of valves. The incidence of drilling for the different size intervals was relatively evenly distributed for *G. glycimeris* the maximum not exceeding twice the minimum while the maximum for the two donacids easily exceeded five times the minimum. (See Table 1).

One valve, left or right, was not preferred over the other but the umbone region of each valve was definitely preferred as a drilling site.

Table 1

Numbers of valves, total and drilled, by intervals of the sand dwelling bivalve molluscs, *Glycimeris glycimeris* (L.), *Donax semistriatus* Poli and *Donax trunculus* L. screened from the sand at a series of eleven regularly spaced stations at Jnah' Beach, south of Beirut, Lebanon. Percentages of each interval drilled (by gastropods) appear in parentheses.

Size interval in mm.	Total Number of Valves			Number of Valves Drilled		
	<i>G. gly-</i> <i>cimeris</i>	<i>D. semi-</i> <i>striatus</i>	<i>D.</i> <i>trunculus</i>	<i>G.</i> <i>glycimeris</i>	<i>D.</i> <i>semistriatus</i>	<i>D.</i> <i>trunculus</i>
0-4	1,548	111	81	250 (16.1)	5 (4.5)	2 (2.5)
4-8	6,427	1,213	709	1,009 (15.7)	34 (2.8)	40 (5.6)
8-12	2,052	1,301	718	456 (22.2)	66 (5.1)	56 (7.8)
12-16	477	1,012	451	126 (26.4)	113 (11.2)	31 (6.9)
16-20	184	442	268	34 (18.5)	71 (16.1)	14 (5.2)
20-24	68	66	416	11 (16.2)	6 (9.1)	6 (1.4)
24-28	36	1	993	—	—	4 (0.4)
28-32	11	—	788	—	—	3 (0.4)
32-36	6	—	24	—	—	—
Totals	10,809	4,146	4,448	1,886 (17.4)	295 (7.1)	156 (3.5)

DISCUSSION

In order to provide a framework for discussion a series of working assumptions (with justifications) are presented. It is assumed that, 1) as there is no evidence for a long term trend for the beach to accumulate entire valves an annual equilibrium situation exists, *i.e.*, the same number of valves are removed from the beach as are contributed to it each year, 2) as the beach in question falls between two rocky headlands shell debris found on it is autochthonous, 3) as very few valves can be found on either the surface or buried after storms, storms remove shell debris from the area, 4) as shell debris appearing on the beach after storms is composed primarily of valves still linked together by their ligaments and, of valves of a glossy character showing negligible abrasion these valves are the result of recent mortality during the period after the storm, 5) as almost all types of materials are hydrographically sorted we must expect to see at least some sorting for mollusc valves, 6) as holes produced by drilling gastropods are small, they do not significantly alter the hydrodynamic properties of the valve, 7) that for every valve exhibiting a hole drilled by a mollusc there is a paired valve without any sign of drilling, *i.e.* if 50% of a certain sample of valves were drilled 100% contribution to mortality can be attributed to boring mol-

luscs, 8) as the shells concerned are not particularly attractive, are small and are present in large numbers shell collectors do not significantly distort the situation, 9) as the mobility of the substrate is an important factor in determining the release of valves for wave transport the sample area is defined as the zone of unstabilized sand, *i.e.* showing sand ripples, etc., 10) as density, the ratio of surface area to volume, and shape are approximately constant for different sizes for any one species, the mobility from the site of origin to the exposed shore is approximately similar, for all sizes of valves, 11) and finally, as density dependent, density independent and « hybrid » mortality factors are quite likely to be acting graphs of valve dimension versus frequency cannot be fully reflective of population structure.

The assumptions and justifications appearing as items in the preceding paragraph permit us to consider the data presented as a partial statement on the contribution to mortality of three species of bivalve mollusc for the period following the previous storm. The most meaningful contribution is the idea that the percentage of mortality (total and by size interval) due to drilling molluscs is a reasonable approximation and this information should be useful to the theoretical population dynamicist interested in data on natural populations. To the best of the author's knowledge there is very little of this type of data available. It is striking to learn that for *G. glycymeris* 52.1% is the contribution to mortality within the 12 to 16 mm. length interval due to boring molluscs.

Per-centage mortality due to drilling molluscs is also high for *Donax semistriatis* with a high of 32% for the 16 to 20 mm. size interval. The data for all intervals summarized is 14.2%. Compared with the total mortality for *D. trunculus* of 7% the differential in mortality due to drilling molluscs is quite significant. When one considers how the approximate similarity in size, shape and habitat for these two species this contrast in the character of mortality is indeed significant. The bimodality of the length-frequency data as opposed to the unimodality of drilling per-centage mortality for *D. trunculus* is noteworthy. It appears that drills are not particularly able to utilize the productivity of the larger size intervals of both *D. trunculus* and *G. glycymeris*.

The variability of the data from sample site to sample site is great thus further supporting our assumption on hydrodynamic sorting. Compare, in example sites 9 and 11. (Table II) In site 9 *D. trunculus*

due to hydrodynamic factors.

Table 2

		North											Samples Sites											South										
Size interval in mm.	D.s.	1		2		3		4		5		6		7		8		9		10		11		Totals										
		D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.	D.t.	D.s.											
0-4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	37	31	74	50	111	81										
4-8	53	35	—	—	11	15	5	3	—	—	107	138	34	34	52	43	72	70	247	128	632	244	1,213	710										
8-12	134	75	44	21	60	38	27	6	6	5	184	77	112	61	64	28	182	147	164	159	324	101	1,301	718										
12-16	83	50	59	19	77	21	59	19	10	9	111	49	135	45	39	11	186	92	116	86	137	50	1,012	451										
16-20	23	26	31	15	26	12	36	14	3	4	44	11	71	39	19	4	103	74	52	44	34	25	442	268										
20-24	4	51	12	26	2	10	4	21	2	14	6	17	10	60	—	8	14	123	6	58	6	28	66	416										
24-28	—	87	—	44	—	10	—	38	—	18	—	26	1	180	—	21	—	337	—	186	—	46	1	993										
28-32	—	66	—	18	—	6	—	43	—	13	—	12	—	145	—	19	—	324	—	109	—	33	—	788										
32-36	—	2	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	12	—	1	—	4	—	24										
		297	146	176	131	21	452	363	174	557	622	1,207	4,146	581	802	1,179	134	569	330	63	144	112	143	392	143									

exceeds *D. semistriatus* by about two to one whereas in sample 11 the situation is just reversed. These differences are quite significant because the samples are of large size. Within these same samples we note that for *D. trunculus* the lower mode is dominant for site 11 whereas the greater length mode is dominant for site 9. The modal values for *D. semistriatus* are also quite different with the 11 to 16 mm. interval dominating in site 9 whereas the 4 to 8 mm. interval dominates in site 11. Such differences appear throughout the data. It is difficult to say whether these differences are always due primarily to hydrodynamic sorting, to differences in the off shore population structure or a combination of these two. Such variability casts considerable doubt on the possibility of beached valve litter being used as a simple analog of offshore population structure.

Worthwhile questions which have been overlooked in this study are, 1) the relationship of the length-frequency data for the beached valves and the values of the natural populations, 2) the specialization that has taken place among the three or four local species of *Natica* and the three species of bivalve that are discussed and, 3) the relationship of predator size as detectable by the size of the drill hole and the size of the prey.

Little need be said about the preference of the drilling predators for the umbone region. This site is closer to the vulnerable parts such as the heart, ganglia, and other organs of the visceral mass and most likely represents a stereotyped feeding pattern imparting greater predational efficiency.

The general applicability of this procedure of evaluating the contribution to mortality (or percentage mortality) appears to depend upon hydrographic and meteorological conditions that alternately move mollusc valves landward and then remove them seaward so that they will not distort the short term representation of the data. The levant coast of the Mediterranean seems generally appropriate for this type of study.

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ABSTRACT

10,809, 4,146 and 4,448 valves of *Glycimeris glycimeris* (L.), *Donax semistriatus* Poli and *D. trunculus* L., respectively, were collected at Jnah' Beach, Beirut, Lebanon. 17.4, 7.1 and 3.5%, respectively, bore holes of the drilling gastropods, *Natica* spp. Thus approximated contribution to mortality ranged from a high of 52.8% for the 12 to 16 mm. valve length interval of *G. glycimeris* to a negligible contribution (less than 1%) for all three species above 24 mm. These statistics seem applicable to a restricted period of time due to local hydrographic and meteorological conditions which alternately add valves and remove valves from the beach studied.

G E N O V A

FRATELLI PAGANO - TIPOGRAFICI EDITORI - S. A. S.

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